DYNAMICS

3

KIPS MULTIPLE CHOICE QUESTIONS

1. **Laws of motion was presented by:**
   a) Einstein b) Newton c) Galileo d) Archimedes
2. **Isaac Newton described the laws of motion in his famous book:**
   a) Qanoon-ul-Masoodi b) Principia Mathematica
   c) Kitab-ul-Astralab d) Al-Manazir
3. **The laws of motion established the relationship between motion and --------:**
   a) Force b) Torque c) Acceleration d) Momentum
4. **First law of motion is also know as law of ----------:**
   a) Torque b) Acceleration c) Inertia d) None of these
5. **---------- of a body is the direct measure of inertia:**
   a) Mass b) Energy c) Momentum d) All of above
6. **The characteristic of a body due to which it tends to retain its state of rest or of uniform motion is known as:**
   a) Weight b) Force c) Inertia d) Momentum
7. **---------- is the agency which changes or tends to change the state of rest or of uniform motion of a body:**
   a) Weight b) Force c) Inertia d) Momentum
8. **Law of inertia is actually the ---------- law of motion:**
   a) First b) Second c) Third d) Fourth
9. **When a force is applied on the body, ---------- is produced in the body:**
   a) Weight b) Acceleration c) Energy d) None of the above
10. **The acceleration produced in a moving body is always in the direction of applied ----------:**
    a) Velocity b) Force c) Speed d) Momentum
11. **If mass of the body is doubled while keeping the force constant, then acceleration will be:**
    a) One half b) doubled c) One fourth d) Four times
12. **If force applied on the body is doubled while keeping the mass constant, then acceleration will be:**
    a) One half b) doubled c) One fourth d) Four times
13. **SI unit of force is:**
    a) Kilogram b) Dynes c) Newton d) Pound
14. **When a force of 8 Newton is applied on a body of mass 2 Kg, then the acceleration produced will be:**
    a) 16 ms^{-2} b) 4 ms^{-2} c) 0.4 ms^{-2} d) 160 ms^{-2}

15. 1 N = ----------
a) $Kgms^{-2}$ b) $Kgms^{-1}$ c) Kgm^2s^{-1} d) Kg^2ms^{-2}

16. **Action and reaction are equal in magnitude but opposite in direction is known as --- ---------- law of motion:**
a) First b) Second c) Third d) Fourth

17. **Walking on road is an example of ---------- law of motion:**
a) First b) Second c) Third d) Fourth

18. **When a block is lying on a smooth surface, its weight is balanced by:**
a) Mass b) Momentum c) Inertia d) Normal Reaction

19. **The weight of a body of mass 10 Kg on earth will be ----------:**
a) 10 N b) 1 N c) 100 N d) 1000 N

20. **The ---------- of a body always acting towards the center of the earth:**
a) Mass b) Force c) Velocity d) Weight

21. **Quantity of matter in a body:**
a) Mass b) Force c) Velocity d) Weight

22. **The Force with which earth attracts a body towards its center is known as:**
a) Mass b) Force c) Weight d) Inertia

23. **The characteristic of a body which determines the magnitude of acceleration produced when a certain force acts upon it:**
a) Mass b) Force c) Inertia d) Weight

24. **Mass of the body is measured by:**
a) Free Fall Apparatus b) Physical balance
c) Spring balance d) All of above

25. **Weight of the body is measured by:**
a) Free Fall Apparatus b) Physical balance
c) Spring balance d) All of above

26. **Unit of weight is:**
a) Kg b) ms^{-1} c) Nm d) N

27. **---------- of a body remains same every where:**
a) Weight b) Acceleration c) Velocity d) Mass

28. **---------- of a body does not remain same every where:**
a) Weight b) Inertia c) Mass d) All of above

29. **The value of weight of a body of constant mass depends on:**
a) Inertia b) Momentum c) Force d) 'g'

30. **Mass is a ---------- quantity:**
a) Scalar b) Vector c) Derive d) Negative

31. **Weight is a ---------- quantity:**
a) Scalar b) Vector c) Derive d) Negative

32. **When a block is hanging with the help of a rope then weight of the body is balanced by:**
a) Acceleration b) Inertia c) Displacement d) Tension

33. **There are -------- cases of motion of the body hanging with the help of rope:**
a) 1 b) 2 c) 3 d) 4

34. **The tension produced when one body moves vertically and the other moves horizontally is ---------- as compared to the tension produced when both bodies move vertically:**
a) Half b) One fourth c) Double d) Four times

35. **Quantity of motion in a body is known as:**
a) Mass b) Momentum c) Velocity d) Acceleration

36. **Product of mass and velocity is known as:**
a) Force b) Speed c) Momentum d) Acceleration

37. **SI unit of Momentum is:**
a) $Kgms^{-2}$ b) Ns c) $Kgms^{-1}$ d) Both b & c

38. **$Kgms^{-1}$ = ----------**
a) N b) J c) Ns d) W

39. **Rate of change of momentum is equal to:**
a) Force b) Velocity c) Acceleration d) Impulse

40. **Direction of the rate of change of momentum is in the direction of:**
a) Acceleration b) Momentum c) Velocity d) Force

41. **The force which resists the motion of one surface on another surface is known as:**
a) Gravity b) Friction c) Weight d) Repulsion

42. **When object is at rest, the force of friction is known as ---------- friction:**
a) Static b) Limiting c) Kinetic d) Dynamics

43. **The maximum value of static friction is known as ---------- friction:**
a) Static b) Limiting c) Kinetic d) Dynamics

44. **When an object is in motion then the force of friction is known as -----friction:**
a) Static b) Limiting c) Kinetic d) Dynamics

45. **Static friction is ---------- than kinetic friction:**
a) Less b) Quartered c) Greater d) Equal

46. **Rolling friction is ---------- than Sliding friction:**
a) Less b) Quartered c) Greater d) Equal

47. **The coefficient of friction has ---------- unit:**
a) Newton b) Dynes c) No d) Kilogram

48. **Friction of liquids is ---------- than friction of solids:**
a) Less b) Quartered c) Greater d) Equal

49. **Coefficient of kinetic friction does not depend upon the ---------- between two surfaces:**
a) Area of contact b) Normal Reaction c) Weight d) Roughness

50. **The rolling friction is about ---------- times smaller than sliding friction:**
a) 10 b) 50 c) 100 d) 1000

51. **Friction in the human joints is much reduced due to the presence of:**
a) Bones b) Muscles c) Fluid d) Gas

52. **Value of coefficient of kinetic friction (μ_k) depends upon:**
a) Nature of the surfaces b) Area of contact
c) Force d) All of above

53. **The Rotation of water sprinkler is an example of ---------- law of motion:**
a) First b) Second c) Third d) Fourth

54. **A spider web remains intact due to:**
a) Weight b) Momentum c) Tension d) None of these

55. **Momentum of a moving body depends upon its:**
a) Mass b) Velocity c) Weight d) Both a & b

56. **Motion of the rocket is an example of:**
a) First law of motion b) Law of conservation of Momentum
c) Law of conservation of Energy d) Weight

57. **Value of coefficient of static friction (μ_s) is usually ---------- than coefficient of kinetic friction (μ_k):**
a) Less b) Quartered c) Greater d) Equal

58. **When air is released from an inflated balloon, it shoots off is an example of:**
a) First law of motion
b) Law of conservation of Energy
c) Weight
d) Law of conservation of Momentum

59. **Sliding friction is commonly converted into Rolling friction by the use of:**
a) Ball bearing b) Oil c) Grease d) Polish

60. **The front sides of high speed vehicles, aeroplanes and ships are shaped wedge like to reduce:**
a) Weight b) Pressure c) Speed d) Friction

ANSWER KEY

Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans
1	b	11	a	21	a	31	b	41	b	51	c
2	b	12	b	22	c	32	d	42	a	52	a
3	a	13	c	23	a	33	b	43	b	53	c
4	c	14	b	24	b	34	a	44	c	54	c
5	a	15	a	25	c	35	b	45	c	55	d
6	c	16	c	26	d	36	c	46	a	56	b
7	b	17	c	27	d	37	d	47	c	57	c
8	a	18	d	28	a	38	c	48	a	58	d
9	b	19	c	29	d	39	a	49	a	59	a
10	b	20	d	30	a	40	d	50	c	60	d

KIPS SHORT QUESTIONS

Q.1 Define dynamics.

Ans: The branch of mechanics that deals with the study of motion of an object and the cause of its motion is called dynamics.

Q.2 Define force

Ans: A force moves or tends to move, stops or tends to stop the motion of a body. The force can also change the direction of motion of a body.

Example

We can open the door either by pushing or pulling the door.

A man pushes the cart. The push may move the cart or change the direction of its motion or may stop the moving cart.

A batsman changes the direction of moving ball by pushing it with his bat.

Q.3 Define inertia

Ans: Inertia of a body is its property due to which it resists any change in its state of rest or of uniform motion.

It depends on the mass of the body. Greater the mass of the body greater will be the inertia. Therefore, we can say that mass is the direct measure of inertia.

Q.4 What is momentum?

Ans: Momentum of a body is the quantity of motion it possesses due to its mass and velocity. The momentum 'P' of a body is given by the product of its mass m and velocity v. Thus

$P = m \times v$

Quantity

Momentum is a vector quantity.

Unit

SI unit of momentum is kg ms^{-1} or Ns.

Q.5 State Newton's First law of motion.

Ans: A body continues in its state of rest or of uniform motion in a straight line provided no net force acts on it.

Q.6 Why Newton's First law of motion is also called law of inertia?

Ans: Since Newton's first law of motion deals with the inertial property of matter, therefore, Newton's first law of motion is also known as law of inertia.

Q.7 State Newton's Second law of motion

Ans: "When a net force acts upon a body, it produces an acceleration in the body direction of force and the magnitude of acceleration is directly proportional to the force and is inversely proportional to the mass of the body".

Q.8 What is the unit of force? Define it.

Unit of Force

In the System International, the unit of force is Newton, which is represented by the symbol **'N'**.

Newton

"One Newton is that force which produces an acceleration of 1 ms^{-2} in a body of mass 1 Kg".

This unit of force can also be written as,

$1\ N = 1\ kg \times 1\ ms^{-2}$

$1\ N = 1\ Kgms^{-2}$

Q.9 State Newton's Third law of motion

Ans: "To every Action there is always a reaction which is equal in magnitude but opposite in direction".

Q.10 If a moving body has no acceleration; does it mean that no force is acting on it?

Ans: According to Newton's second law of motion, we have

$F = ma$

When acceleration = $a = 0$, we get

$F = m \times 0$

So, $F = 0$

Thus, when acceleration is zero then the net force acting on the body is zero but it does not mean that no force is acting on the body. When body is in motion, some forces be acting on the body but in case of zero acceleration, net (resultant) force should be zero.

Q.11 What do you know about Momentum?

Ans: Definition

The Momentum of the moving body is the product of its mass and velocity.

OR

Quantity of motion of the body is determined by a quantity known as Momentum.

Mathematical Form

If a body of mass 'm' is moving with velocity 'v' then mathematically it is written as,

$P = m \times v$

Quantity

Momentum is a vector quantity.

Unit

The SI unit of momentum is ($Kgms^{-1}$). It can also be written as (Ns).

Q.12 Prove that $1kgms^{-1} = 1Ns$

Ans: L.H.S

$1\ kgms^{-1} = 1kg \times 1ms^{-1} \times 1s/1s$

$= 1kgms^{-2} \times 1s$

As we know that $1kgms^{-2} = 1N$

So $1kgms^{-1} = R.H.S = 1\ N\ s$

OR

R.H.S

$1\ Ns$

As $N = kg\ ms^{-2}$

So $Ns = kg\ ms^{-2} \times s = kg\ ms^{-2} = L.H.S$

So $kg\ ms^{-1} = Ns$

Q.13 On which quantities, Momentum (quantity of motion) of a body depends?

Ans: Momentum or quantity of the motion of a body depends on two quantities.

(i) Mass of the body

(ii) Velocity of the body

Q.14 What is the relationship of momentum and the force applied on the body?

Ans: Rate of change of momentum of a body is equal to the applied force on it and the direction of change in momentum is in the direction of the force.

Q.15 State law of conservation of momentum.

Ans: The momentum of an isolated system of two or more than two interacting bodies remains constant.

An isolated system is a group of interacting bodies on which no external force is acting. If no unbalanced or net force acts on a system then its momentum remains constant.

Q.16 Write down the advantages and disadvantages of friction.

Ans: Disadvantages

- Friction is undesirable when moving at high speed because it opposes the motion and thus limits the speed of the moving objects.
- Most of our useful energy is lost as heat and sound due to the friction between various moving parts of machines.
- In machines, friction is also causes wear and tear of their moving parts.

Advantages

- We cannot write if there would be no friction between paper and the pencil.
- Friction enables us to walk on the ground.
- We cannot run on a slippery ground. A slippery ground offers very little friction. Hence, anybody who tries to run on a slippery ground may meet an accident. Similarly, it is dangerous to apply brakes with full force to stop a fast moving vehicle on a slippery road.
- Birds could not fly, if there is no air resistance. The reaction of pushed air enables the birds to fly.

Q.17 Write down the methods to reduce friction.

Ans: The friction can be reduced by:

- Making the sliding friction smooth
- Making the fast moving a streamline shape (fish shape) such as car, aeroplanes, etc. this causes the smooth flow of air and thus minimizes air resistance at high speeds.
- Lubricating the sliding surfaces
- Using ball bearings or roller bearings. Because the rolling friction is lesser than the sliding friction.

Q.18 What is Sliding friction?

Ans: The frictional force opposing the sliding or dragging on of one solid body over another solid body is called sliding friction.

Q.19 Why is the rolling friction is less than sliding friction?

Ans: When a wheel moves on a smooth surface, it has the contact with the surface only at a single point. As there is no relative motion between the two surfaces at this point, therefore, sliding friction is zero. However, practically, the wheel is compressed a little at the contact point of the two surfaces under stress. Because of that little sliding friction, the rolling friction is produced and less than sliding friction.

Q.20 Suppose you are running and want to stop at once. Surely you will have to produce negative acceleration in your speed. Can you tell from where does the necessary force come?

Ans: While running when we want to stop at once, we press the ground firmly with our feet. Thus friction comes into play due to relative motion of our feet and ground which acts opposite direction to our motion and it reduces our speed and ultimately we come to stop.

Q.21 Define circular motion.

Ans: Motion of the body moving in the circular path is known as circular motion. Heavenly bodies have natural tendency to move in curved paths.

Examples

- The motion of the moon around the Earth is nearly in circular orbit.
- The paths of electrons moving around the nucleus in an atom are also nearly circular.
- Motion of the stone tied with the string

Q.22 Define centripetal force

A force that keeps a body to move in a circle is known as centripetal force.

Or

A force which compels the body to move in the circular path is known as centripetal force.

Q.23 Define centripetal acceleration

The acceleration produced by the centripetal force which is always directed towards the center of the circle is known as centripetal acceleration. It is represented by a_c.

Q.24 Define and explain centrifugal force. Is it a reaction of centripetal force?

Ans: Definition

According to Newton's third law of motion, there exists a reaction to centripetal force. Centripetal reaction that pulls the bodies in outwards direction is called the centrifugal force.

Example

Consider a stone tied with a string moving in a circle. The necessary centripetal force acts on the stone through the string that keeps it in the move in a circle. According to Newton's third law of motion, there exists a reaction to centripetal force. Centripetal reaction that pulls the string outward is sometimes the centrifugal force.

Q.25 Why outer edge of the road is kept higher than inner edge (banking of road)? Explain.

Ans: When a car takes a turn, centripetal force is needed to keep it in its curved track. The friction between the tyres and road provides the necessary centripetal force. The car would skid away if the force of friction between the tyres and the road is not sufficient enough particularly when the roads are wet. Banking of a road means that the outer edge of a road is raised. Banking causes a component of vehicle's weight to provide the necessary force while taking a turn. Thus banking of road prevents skidding of vehicle and thus makes the driving safe.

Q.26 Explain the function of washing machine (dryer).

Ans: The dryer of a washing machine is basket spinner. They have perforated wall having large numbers of fine holes in the cylindrical rotor. The lid of the cylindrical container is closed after putting wet clothes in it. When it spins at high speed, the water from wet clothes is forced out through these holes due to lack of centripetal force.

Q.27 Explain the function of cream separator.

Ans: Most modern plants use a separator to control the fat contents of various products. A separator is a high – speed spinner. It acts on the same principle of centrifuge machine. The bowl spins at very high speed causing the heavier contents of the milk to move outwards in the bowl pushing the lighter contents inwards towards the spinning axis. Cream or butterfat is lighter than other components in the milk. Therefore, skimmed milk, which is denser than cream is collected at outer wall of the bowl. The lighter part (cream) is pushed towards the center from where it is collected through a pipe.

Q.28 Why a cyclist bend himself toward the inner side of the curved path while taking turn with high speed?

Ans: A cyclist bend himself toward the inner side of the curved path while taking turn with high speed to provide necessary centripetal force with his weight to take turn in circular path to avoid slipping.

Q.29 What is centrifuge? And what is the principle of centrifuge?

Ans: Centrifuge is one of the most useful laboratory instruments. It helps to separate out heavy and light particles from the mixture.

Principle

If the magnitude of applied force falls short of required centripetal force then the object will move away from the centre of the circle. The centrifuge functions on this basic principle.

Q.30 Can a body move with uniform velocity in a circle? If not, why?

Ans: When a body is moving in circle it may have uniform speed but its velocity is non-uniform because direction of the body is changing at every instant.

Q.31 Can a body move along a circle without the centripetal force?

Ans: When a body moves in a circular path, it does so under the action of centripetal force. This force is directed towards the center along the radius of the circle. As the radius is perpendicular to the tangent of the circle, the centripetal force keeps the body in circular path. Thus, in absence of centripetal force, the body cannot move in a circular path.

Q.32 Moon revolves around the earth, from where it gets necessary centripetal force?

Ans: The gravitational force between the earth and the moon provides the necessary centripetal force to moon for revolving around the earth.

LONG QUESTIONS

3.2 NEWTON'S LAWS OF MOTION

Newton's First Law of Motion

Q.No.1 State and Explain Newton's First law of motion

Ans: A body continues in its state of rest or of uniform motion in a straight line provided no net force acts on it.

Explanation for rest

Newton's first law of motion deals with bodies which are either at rest or moving with uniform speed in straight line. According to first law of motion, a body at rest remains at rest provided no net force act on it. This part of the law is true as we observe that objects do not move by themselves unless someone moves them.

Example

A book lying on a table remains at rest as long as no net force acts on it.

Explanation for motion

Similarly, a moving object does not stop moving by itself. A ball rolled on a rough ground stops earlier than that rolled on smooth ground. It is because rough surface offer greater friction. If there would be no force to oppose the motion of the body would never stop.

Example

When its engine of a car moving with uniform velocity is turned off it stops gradually because a net force of friction is acting in the opposite direction causes to stop it.

Law of inertia

Since Newton's first law of motion deals with the inertial property of matter, therefore, Newton's first law of motion is also known as law of inertia.

Example

Passengers standing in a bus fall forward when its driver applies brakes suddenly. It is because the upper parts of the bodies tend to continue their motion, lower parts of their bodies are in contact with the bus stop with it. Hence, they fall forward.

Net Force

Net force is the resultant of all the forces acting on a body.

Newton's Second Law of Motion

Q.No.2State and Explain Newton's Second law of motion

Ans: "When a net force acts upon a body, it produces as acceleration in the body direction of force and the magnitude of acceleration is directly proportional to the force and is inversely proportional to the mass of the body".

Dependence of acceleration

Acceleration produced in the body depends upon two factors

1. Force
2. Mass

Mathematical Form

If the force 'F' is acting on the body of mass 'm' then we can write this in the mathematical form as,

$$a \alpha F \quad \ldots\ldots\ldots\ldots (1)$$

$$a \alpha \frac{1}{m} \quad \ldots\ldots\ldots\ldots (2)$$

From relation (1) and (2), we have

$$a \alpha \frac{F}{m}$$

Changing the sign of proportionality into the sign of equality

$$a = \text{constant} \times \frac{F}{m}$$

$$a = k \times \frac{F}{m}$$

In above equation, according to international system of units if m = 1Kg, $a = 1ms^{-2}$, F = 1N then the value of the constant k will be '1'. So the equation can be written as,

$$a = 1 \times \frac{F}{m}$$

$$F = ma$$

This is the mathematical form of Newton's Second law of motion.

Unit of Force

In the System International, the unit of force is Newton, which is represented by the symbol **'N'**.

Newton

"One Newton is that force which produces an acceleration of 1 ms^{-2} in a body of mass 1 Kg". This unit of Newton can also be written as,

$$1 N = 1 kg \times 1 ms^{-2}$$

$$1 N = 1 Kgms^{-2}$$

Q.No.3Differentiate between Mass and Weight.

Ans:

Mass	Weight
• Mass of a body is the quantity of matter possessed by the body.	• The weight of the body is equal to the force with which earth attracts it.
• It is a scalar quantity.	• It is a vector quantity and is toward the center of the earth.
• It is measured by physical balance.	• It is measured by spring balance.
• It remains same everywhere and does not change with change of place.	• It does not remain same at all places and varies with the value of 'g'.
• Unit of mass is kilogram (Kg).	• Unit of weight is Newton (N).
• It is a base quantity.	• It is a derived quantity.
• It can be calculated by using the formula F = ma.	• It can be calculated by using the formula w = mg.

Newton's Third Law of Motion

Q.No.4State and Explain Newton's Third law of motion

Ans: "To every Action there is always a reaction which is equal in magnitude but opposite in direction".

Action and Reaction

Newton's third law of motion deals with the reaction of a body when a force acts on it. Let a body A exerts a force on another body B, the body B reacts against this force and exerts a force on body A. the force exerted by body A on B is the action force whereas the force exerted by B on A is called the reaction force.

Relation between Action and Reaction

Newton has expressed action and reaction in his third law of motion. Action is always accomplished by a reaction force and the two forces must always be equal and opposite. It is to remember that "action" and "reaction" do not act on the same body but they act on two different bodies.

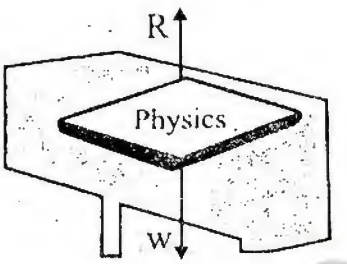

Figure 3.8: Action of the book and reaction on it.

Example 1

Consider a book lying on a table as shown in figure. The weight of the book is acting on the table in the downward direction. This is the action. The reaction of the table acts on the book in the upward direction.

Example 2

Take an air – filled balloon as shown in figure. When the balloon is set free, the air inside it rushes out and the balloon moves forward. In this example, the action is by the balloon that pushes the air out of it when set free. The reaction of the air which escapes out from the balloon acts on the balloon. It is due to this reaction of the escaping air that moves the balloon forward.

Figure 3.9: Reaction of the air pushed out of the balloon moves it.

Example 3

A rocket such as shown in figure moves on the same principle. When its fuel burns, hot gases escape out from its tail with a very high speed. The reaction of these gases on the rocket causes it to move opposite to the gases rushing out of its tail.

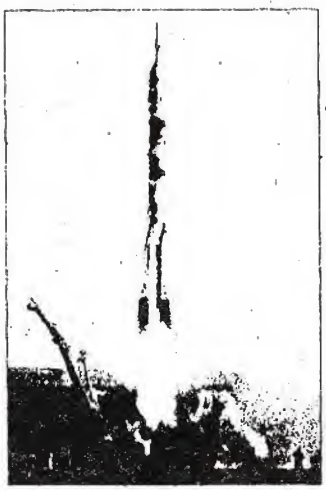

Figure 3.10: A Rocket taking off

Tension and Acceleration in a String

Q.No.5 Explain the tension in the string. If two bodies of masses m_1 and m_2 are hanging from the two ends of a string which is passing over a pulley, find the values of tension and acceleration in it.

Ans: The force which is exerted by the string on the body is called the tension in the string. It is a reaction force of the weight and it is usually denoted by T. The weight acts downwards while tension T in the string is acting upwards at the block. If the object is at rest, the magnitude of tension is equal to weight.

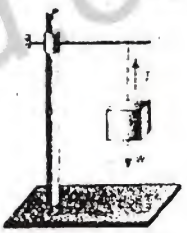

Figure 3.11: Weight of the block pulls the string downwards

Motion of Bodies connected by a string

There are two cases of motion of bodies connected by a string.

(i) When the bodies move vertically

(ii) When one body moves vertically and the other moves horizontally

Case-I

When the Bodies Move Vertically

Suppose two bodies A and B having masses m_1 and m_2 respectively are connected to two ends of an inextensible string which passes over a frictionless pulley. If m_1 is greater than m_2, then the body A will move downward and the body B will move upward. The body A being heavier must be moving downwards with some acceleration. Let this acceleration be a. At the same time, the body B is attached to the other end of the string moves up with the same acceleration a. as the pulley is frictionless, hence tension will be the same throughout the string. Let the tension in the string be T.

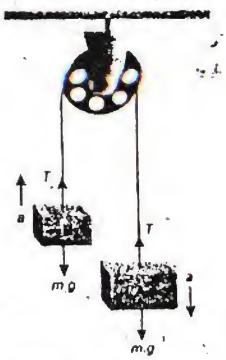

Figure 3.12: Bodies attached to the ends of a string that passes over a frictionless pulley.

Forces acting on the body A

As the body A is moving downward, the resultant force acting on it is downward due to which acceleration a is produced in it.

Net force acting on body A = $m_1g - T$

According to Newton's second law of motion;

$$m_1g - T = m_1a \quad \ldots\ldots\ldots\ldots (1)$$

As the body B is moving upward, the resultant force acting on it is upward due to which acceleration a is produced in it.

Net force acting on body B = $T - m_1g$

According to Newton's second law of motion;

$$m_2g - T = m_2a \quad \ldots\ldots\ldots\ldots (2)$$

Calculation of Acceleration

By adding equation (1) and equation (2), we have

$$m1g - T + T + m_2g = m_1a + m_2a$$

$$m_1g - m_2g = m_1a + m_2a$$

$$(m_1 - m_2)g = (m_1 + m_2)a$$

$$\frac{(m_1 - m_2)g}{m_1 + m_2} = a$$

OR $$a = \frac{(m_1 - m_2)g}{m_1 + m_2} \quad \ldots\ldots\ldots\ldots (3)$$

Calculation of Tension

By putting the value of 'a' in equation (2), we have

$$T - m_2g = m_2 \times \frac{(m_1 - m_2)g}{m_1 + m_2}$$

$$T - m_2g = \frac{m_2g(m_1 - m_2)}{m_1 + m_2}$$

By adding m_2g on both sides, we have

$$T - m_2g + m_2g = \frac{m_2g(m_1 - m_2)}{m_1 + m_2} + m_2g$$

$$T = \frac{m_2g(m_1 - m_2) + m_2g(m_1 + m_2)}{m_1 + m_2}$$

$$T = \frac{m_1m_2g - m_2^2g + m_1m_2g + m_2^2g}{m_1 + m_2}$$

$$T = \frac{2m_1m_2g}{m_1 + m_2} \quad \ldots\ldots\ldots\ldots (4)$$

The above arrangement is also known as Atwood machine. It can also used to find the acceleration due to gravity by equation (3)

$$g = \frac{m_1 + m_2}{m_1 - m_2} a$$

Case-II

When One Body Moves Vertically and the Other Moves Horizontally

Two bodies A and B having masses m_1 and m_2 respectively are connected to an inextensible string which passes over the pulley as shown in figure. The body A moves vertically downward with an acceleration a. The body B moves on the horizontal smooth surface towards the pulley with the same acceleration a. As the pulley is frictionless, hence tension T will be the same throughout the string.

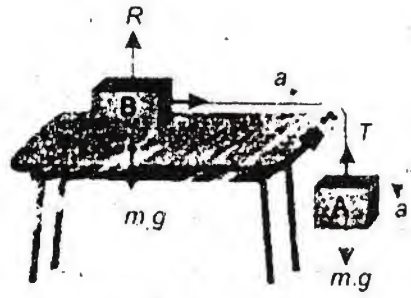

Figure 3.13: Motion of masses attached to a string that passes over a frictionless pulley.

Forces acting on the body A

As the body A is moving downward, therefore, weight m_1g is greater than the tension T in the string.

Net force acting on body A = $m_1g - T$

According to Newton's second law of motion;

$$m_1g - T = m_1a \quad \ldots\ldots\ldots\ldots (1)$$

Forces acting on the body B

Now consider the motion of the body B. Three forces are acting on it.

(i) Its weight $w_2 = m_2g$ of the body B acting downward

(ii) The upward reaction R on the horizontal surface acting on the body B in the upward direction.

(iii) Tension T on the string pulling the body in the horizontal direction over the smooth surface.

As the body B is not moving vertically, therefore, vertical forces cancel each other and their resultant is zero. The only remaining force T due to which the body B is moving in the horizontal direction with acceleration 'a'.

Hence according to Newton's second law of motion,

$$T = m_2a \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Calculation of Acceleration

By putting the value of T in equation (1), we have

$$m_1g - m_2a = m_1a$$

$$m_1g = m_1a + m_2a$$

$$m_1g = (m_1 + m_2)a$$

$$\frac{m_1g}{m_1+m_2} = a$$

OR $$a = \frac{m_1g}{m_1+m_2} \quad \ldots\ldots\ldots\ldots (3)$$

Calculation of Tension

In order to find the value of T, put the value of a in equation (2), we have

$$T = m_2 \times \frac{m_1 g}{m_1 + m_2}$$

$$T = \frac{m_1 m_2 g}{m_1 + m_2} \quad \ldots\ldots\ldots\ldots \quad (4)$$

Force and the Momentum

Q.No.6 How you can prove that rate of change in momentum of a body is equal to the applied force?

Ans: When a force acts on a body, it produces an acceleration in the body and will be equal to the rate of change of momentum of the body.

Suppose a force 'F' acts on a body of mass 'm' moving with initial velocity 'v_i' which produces an acceleration a in it. This changes the velocity of body to 'v_f' after time t. If P_i and P_f be the initial momentum and final momentum of the body related to initial and final velocities, Then,

Momentum of the body having velocity $v_i = P_i = mv_i$

Momentum of the body having velocity $v_f = P_f = mv_f$

Change in momentum = final momentum – initial momentum

$$= P_f - P_i = mv_f - mv_i = m(v_f - v_i)$$

$$\text{Rate of change in momentum} = \frac{P_f - P_i}{t} = \frac{mv_f - mv_i}{t}$$

$$\text{Rate of change in momentum} = m\frac{v_f - v_i}{t}$$

Since $\frac{(v_f - v_i)}{t}$ is the rate of change of velocity equal to acceleration produced by the force F.

So $$\frac{P_f - P_i}{t} = ma$$

According to Newton's second law of motion,

$$F = ma$$

So $$\frac{P_f - P_i}{t} = \frac{mv_f - mv_i}{t}$$

So, equation (I) can be written as,

Rate of change in momentum = ma

According to second law of motion, F = ma

So $$\frac{P_f - P_i}{t} = F$$

Rate of change of momentum of a body is equal to the applied force on it and the direction of change of in momentum is in the direction of the force.

Law of Conservation of Momentum

Q.No.7 State and explain Law of conservation of Momentum.

Ans: The momentum of an isolated system of two or more than two interacting bodies remains constant.

An isolated system is a group of interacting bodies on which no external force is acting. If no unbalanced or net force acts on a system then its momentum remains constant.

Example

Consider the example of an air-filled balloon. In this case, balloon and the air inside it form a system. Before releasing the balloon, the system was at rest and hence the initial momentum of the system was zero. As soon as the balloon is set free, air escapes out of it with some velocity. The air coming out of it possesses momentum. To conserve momentum, balloon moves in the direction opposite to the air coming out of it.

Mathematical Explanation

Consider an isolated of two spheres of masses m_1 and m_2 as shown figure. They are moving in a straight line with initial velocities u_1 and u_2 respectively, such that u_1 is greater than u_2. Sphere of mass m_1 approaches the sphere of mass m_2 as they move.

Initial momentum of mass $m_1 = m_1u_1$

Initial momentum of mass $m_2 = m_2u_2$

Total momentum of the system before collision = $m_1u_1 + m_2u_2$

After sometime mass m_1 hits m_2 with some force. According to Newton's third law of motion, m_2 exerts an equal and opposite reaction force on m1. Let their velocities become v_1 and v_2 respectively after collision.

Final momentum of mass $m_1 = m_1v_1$

Final momentum of mass $m_2 = m_2v_2$

Total momentum of the system after collision = $m_1v_1 + m_2v_2$

Total momentum of system before collision = total momentum of system after collision

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

The above equation that the momentum of the isolated system before and after collision remains same which is the law of conservation of momentum.

Application of Law of Conservation of Momentum

This law is applicable universally i.e. true not only for bigger bodies but also for atoms and molecules.

Example

Consider a system of gun and a bullet. Before firing, the velocity of the bullet as well as that of gun was zero. Therefore, the total momentum of both the objects was also zero. We can write it as,

Total momentum of gun and bullet before firing = 0

When the gun is fired, bullet shoots out of the gun and acquire momentum. To conserve momentum the gun recoils backward. Now according to the law of conservation of momentum, the total momentum of the gun and bullet will also be zero after the gun is fired. Let m be the mass of the bullet and v be its velocity on firing the gun; M be the mass of the gun and V be the velocity with which it recoils. Thus the total momentum of the gun is fired will be:

The momentum of the gun and bullet after the gun is fired = M V + m v

According to the law of conservation of momentum

Total momentum before firing = Total momentum after firing

$$M V + m v = 0$$

OR $$M V = - m v$$

Hence $$V = -\frac{m}{M} v$$

The above equation gives the velocity V of the gun. Here negative sign indicates that velocity gun is opposite to the velocity of bullet. That is why the shoulder pressed hard during firing. Since mass of the gun is much larger than the bullet, therefore, the recoil is much smaller than the velocity of the bullet.

Application in Rocket or Jet engine

Rocket or Jet engine also works on this same principle. In both of them, gases are produced at a high temperature due to the burning of fuel. These gases rush out with large momentum. Therefore the rockets or jet engines gain an equal and opposite momentum. This enables them to move with very high velocities.

3.3 FRICTION

Q.No.8 Define friction. Explain cause of friction and derive its mathematical formula.

Ans: The force which opposes the motion of moving objects is called friction.

Cause of friction

No surface is perfectly smooth. A surface that appears smooth has pits and bumps that can be seen under microscope. A magnified view of a surface in contact shows the gaps and contacts between them. The contact points between the two surfaces form a sort of cold welds. These cold welds resist the surfaces from sliding over each other. Adding weight over the upper block increases the force pressing the surfaces together which increases the resistance. Thus greater is the pressing force greater will be the friction between sliding surfaces.

Mathematical Derivation

Friction is equal to the applied force that tends to move a body at rest. This friction at rest is called the static friction. It increases with the applied force. Friction can also be increased to a certain maximum value. It does not increase beyond this. This maximum value of friction is known as force of limiting friction (Fs). It depends on the normal reaction (pressing force) between the two surfaces in contact. The ratio between the force of limiting friction Fs and the normal reaction R is constant. This constant is called the coefficient of friction and is represented by μ.

Thus $$\mu = \frac{Fs}{R}$$

Or $$Fs = \mu R$$

If m is the mass of the block, then for horizontal surface;

$$R = mg$$

Hence $$Fs = \mu mg$$

Friction is desirable

Friction is needed to walk on the ground. It is risky to run on wet floor with shoes that have smooth soles. Athletes use special shoes that have extraordinary ground grip. Such shoes prevent them from slipping while running fast. To stop bicycle we apply brakes. The rubber pads pressed against the rims provide friction. It is the friction that stops the bicycle.

Rolling Friction

Q.No.9 Explain the rolling friction.

Ans: Wheel as greatest invention

The most important invention in the history of mankind was a wheel. The first thing about a wheel is that it rolls as it moves rather than to slide. This greater reduces the friction.

Less friction in Rolling Friction

When axle of a wheel is pushed, the force of friction between the wheel and the ground at the point of contact provides the reaction force. The reaction force acts at the contact points of the wheel in a direction opposite to the direction to the applied force. The wheel rolls without rupturing the cold welds. That is why this rolling friction is extremely small than sliding friction. The fact that rolling friction is less than sliding friction is applied in ball bearing to reduce losses due to friction.

Necessary Road Grip

The wheel would not roll on pushing it if there would be no friction between the wheel and the ground. Thus, friction is desirable for wheels to roll over a surface. It is dangerous to drive on a wet road because the friction between the road and the tyres is very small. This increases the chance of slipping the tyres from the road. The threading of tyres is designed to increase friction. Thus, threading improves road grip and make it safer to drive even on wet road.

Sliding Friction in Brakes

A cyclist applies brakes to stop his/her bicycle. As soon as brakes are applied, the wheels stop rolling and begin to slide over the road. Since sliding friction is much greater than rolling friction, the cycle stops very quickly.

Braking and Skidding

Q.No.10 Explain the roll of friction in Braking and explain the Skidding.

Ans: The wheels of a moving vehicle have velocity components:

(i) Motion of wheel along the road

(ii) Rotation of wheels about their axis

To move a vehicle on the road as well as to stop a moving vehicle requires friction between its tyres and the road.

Example

If the road is slippery or the tyres are worn out then the tyres instead of rolling, slip over the road. The vehicle will not move if the wheels start slipping at the same point on the slippery road. Thus for the wheels to roll, the force of friction (gripping force) between the tyres and the road must be enough that prevents them from slipping.

Similarly to stop a car quickly, a large force of friction between the tyres and the road is needed. But there is a limit to this force of friction that tyres can provide.

Skidding

If the brakes are applied too strongly, the wheels of the car will lock up (stop turning) and the car will skid due to its large momentum. It will lose its directional control that may result in an accident. In order to reduce the chance of skidding, it is advisable not to apply brakes too hard that lock up their rolling motion especially at high speeds. Moreover, it is unsafe to drive a vehicle with worn out tyres.

3.4 UNIFORM CIRCULAR MOTION

Centripetal Force

Q.No.11 Define centripetal force and centripetal acceleration and derive the mathematical relation for centripetal force and acceleration.

Ans: A force that keeps a body to move in a circle is known as centripetal force.

Explanation

Consider a body tied at the end of a string moving with uniform speed in a circular path. A body has the tendency to move in a straight line due to inertia. The string to which body is tied keeps it to move in a circle by pulling the body towards the center of the circle. The string pulls the body perpendicular to its motion. The pulling force continuously changes the direction of motion and remains towards the center of the circle. This center seeking force is called the centripetal force. It keeps the body to move in a circle. Centripetal force always acts perpendicular to the motion of the body.

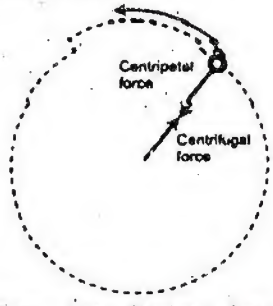

Figure 3.28: Centripetal force acting on the stone and the centrifugal force acting on the

Examples

(i) A stone is tied to one end of a string rotating in a circle. The tension in the string provides the required centripetal force. It keeps the stone to remain in the circle. If the string is not strong enough to provide the necessary tension, it breaks and the stone moves away along the tangent to the circle.

(ii) The moon revolves around the Earth. The gravitational force of the Earth provides required centripetal force.

Mathematical Formula

If an object of mass m is moving with velocity v in a circle of radius r, the magnitude of centripetal force F_c acting on it can be found by using the following equation.

$$F_c = \frac{mv^2}{r}$$

Centripetal acceleration

The acceleration produced by the centripetal force which is always directed towards the center of the circle is known as centripetal acceleration. It is represented by a_c.

According to Newton's second law of motion, the direction of this acceleration is along the direction of the centripetal force F_c, i.e., perpendicular to the velocity and directed towards the centre of the circle.

$$F_c = ma_c$$

So,
$$ma_c = \frac{mv^2}{r}$$

So,
$$a_c = \frac{v^2}{r}$$

Dependence

The above equation shows that centripetal force of the body moving in a circular path depends upon:

- Mass m of the body
- Square of its velocity
- Reciprocal to radius of the circle.

MINI EXERCISE

Stretch out your palm and hold a book on it.

(1) How much force you need to prevent the book from falling?

Ans. Force equal to the weight of the book is needed to prevent the book from falling.

(2) Which is action?

Ans. Weight of the book is action in this case.

(3) Is there any reaction? If yes, then what is its direction?

Ans. Yes there is a reaction offered by hand. The direction of reaction is opposite to the weight.

(4) Which shoe offer less friction?

Ans. Shoe with flat sole will offer less friction

(5) Which shoe is better for walking on dry track?

Ans. On dry track, shoe with flat sole is batter for walking.

(6) Which shoe is better for jogging?

Ans. Shoe which has not flat sole is batter for jogging.

(7) Which sole will wear out early?

Ans. Shoe with flat sole will wear out early.

(8) Why is it easy to roll a cylindrical eraser on a paper sheet than to slide it?

Ans. It is easy to roll a cylinder eraser on a paper sheet than to slide it because rolling friction is less than sliding friction.

(9) Do we roll or slide the eraser to remove the pencil work from our notebook?

Ans. We slide the eraser to remove the pencil work from our notebook because we need more friction to remove the work.

(10) In which case do you need smaller force and why?

(i) rolling (ii) sliding

Ans. **Rolling:** Incase of rolling friction we need smaller force because there is contact with earth on only a single point.

Sliding: Incase of sliding friction we need greater force because all the body is in contact with the earth.

(11) In which case it is easy for the tyre to roll over?

(i) rough ground (ii) smooth ground

Ans. **Rough ground:** Incase of rough ground it is difficult to role over the tyre because rough surface offer more friction.

Smooth ground: Incase of smooth ground it is easier to role over the tyre because smooth surface offer less friction.

TEXTBOOK EXERCISE QUESTIONS

3.1 Encircle the correct answer from the given choices.

i. Newton's first law of motion is valid only in the absence of:

a) Force **b) net force** c) friction d) momentum

ii. Inertia depends upon:

a) Force b) net force **c) mass** d) velocity

iii. A boy jumps out of a moving bus. There is a danger for him to fall:

a) Towards the moving bus
b) Away from the bus
c) In the direction of motion
d) Opposite to the direction of motion

iv. A string is stretched by two equal and opposite forces of 10 N each. The tension in the string is:

a) Zero b) 5 N c) 10 N d) 20 N

v. The mass of a body

a) Decreases when accelerated
b) Increases when accelerated
c) Decreases when moving with high velocity
d) None of the above

vi. Two bodies of masses m_1 and m_2 attached to the ends of an inextensible string passing over a frictionless pulling such that both move vertically. The acceleration of the bodies is:

a) $a = \frac{(m_1 - m_2)g}{m_1 + m_2}$ **b)** $a = \frac{m_1 g}{m_1 + m_2}$ c) $a = \frac{(m_1 + m_2)g}{m_1 - m_2}$ d) $a = \frac{m_2 g}{m_1 + m_2}$

vii. Which of the following is the unit of momentum?

a) Nm b) $kgms^{-2}$ **c) Ns** d) Ns^{-1}

viii. When horse pulls a cart, the action is on the:

a) Cart b) earth c) horse **d) earth and cart**

ix. Which of the following material lowers friction when pushed between metal plates?

a) Water b) fine marble powder c) air **d) oil**

3.2 Define the following terms:

i) Inertia **ii) Momentum** **iii) Force**
iv) Force of friction **v) Centripetal force**

i. Inertia

Ans: See Q.no.3 short Question

ii. Momentum

Ans: See Q.no.4 short Question

iii. Force

Ans: See Q.no.2 short Question

iv. **Force of friction**

Ans: See Q. no.8 Long Question

v. **Centripetal force**

Ans: See Q. no. 22 short Question

3.3 What is the difference between?

i) **Mass and weight**

3.4 Differentiate between Mass and Weight.

Mass	Weight
• Mass of a body is the quantity of matter possessed by the body.	• The weight of the body is equal to the force with which earth attracts it.
• It is a scalar quantity.	• It is a vector quantity and is toward the center of the earth.
• It is measured by physical balance.	• It is measured by spring balance.
• It remains same everywhere. It does not change with change of place.	• It does not remains same at all places because the value of 'g' does remain same at all places.
• Unit of mass is kilogram (Kg).	• Unit of weight is Newton (N).
• It is a base quantity.	• It is a derived quantity.
• It can be calculated by using the formula F = ma.	• It can be calculated by using the formula w = mg.

ii) **Action and reaction**

Action is the applied force while the reaction is produced due to action force. Both forces are equal in magnitude but opposite in direction. They act on different two different bodies.

iii) **Sliding friction and rolling friction**

Sliding Friction	Rolling Friction
Frictional force experienced by the body when a body slides over the other body. It is greater than rolling friction	Frictional force experienced by the body when a body rolls over the other body. It is less than sliding friction

3.5 What is the law of inertia?

Ans: Newton's first law of motion is also called the law of inertia because inertia is the characteristic of body which resists any change in its state of rest or uniform motion.

3.6 Why is it dangerous to travel on the roof of a bus?

Ans: The friction or drag force due to air acting on upper part of the body of a person standing on roof of a running bus, tries to turn over which is dangerous while the lower part of the body is at rest with respect to the roof of the bus.

3.7 Why does a passenger moves outward when a bus takes a turn?

Ans: When the bus is taking turn then it is moving in the circular path. So, passengers sitting inside the bus experience the centrifugal force as the reaction of centripetal force of the bus moving the circular path.

3.8 How can you relate a force with the change of momentum of a body?

Ans: See Q.no.6 Long Question

3.9 What will be the tension in a rope that is pulled from its ends by two opposite forces 100 N each?

Ans: The tension in a rope that is pulled from its ends by two opposite forces 100 N each will be 100 N.

3.10 Action and reaction are always equal and opposite then how does a body move?

Ans: Action and reaction are equal in magnitude but opposite in direction. Action and reaction do not act on the same body. Action is applied on one body due to which an equal and opposite reaction is acting on another body. Both of these do not neutralize each other due to which the body will move.

3.11 A horse pushes the cart. If the action and reaction are equal and opposite then how does the cart move?

Ans: The horse apply action on the road by his feet, the reaction is given by the road on the horse, due to which horse moves. The cart which is tied with the horse will also move.

3.12 What is the law of conservation of momentum?

Ans: The momentum of an isolated system of two or more than two interacting bodies remains constant.

An isolated system is a group of interacting bodies on which no external force is acting. If no unbalanced or net force acts on a system then its momentum remains constant.

3.13 Why is the law of conservation of momentum important?

Ans: With the help of law of conservation of momentum, it is possible to calculate force, velocity, acceleration of a body. Many elementary particles are discovered by using law of conservation of momentum.

3.14 When a gun is fired, it recoils. Why?

Ans: Total momentum of the gun and the bullet is zero before the firing. When gun is fired, bullet moves in forward direction and gun recoils so that total momentum after firing also becomes zero according to law of conservation of momentum.

3.15 Describe two situations in which force of friction is needed?

Ans:

(i) We cannot write if there would be no friction between paper and the pencil.

(ii) Friction enables us to walk on the ground. We cannot run on a slippery ground. A slippery ground offers very little friction.

3.16 How does oiling the moving parts of a machine lower friction?

Ans: As the friction of liquids is less than friction of solids. So oiling the moving parts of the machines lower the friction.

3.17 Describe ways to reduce friction.

Ans: The friction can be reduced by:

- Making the sliding friction smooth
- Making the fast moving a streamline shape (fish shape) such as car, aeroplanes, etc. this causes the smooth flow of air and thus minimizes air resistance at high speeds.
- Lubricating the sliding surfaces
- Using ball bearings or roller bearings. Because the rolling friction is lesser than the sliding friction.

3.18 Why rolling friction is less than sliding friction?

Ans: When a wheel moves on a smooth surface, it has the contact with the surface only at a single point. As there is no relative motion between the two surfaces at this point, therefore, sliding friction is zero. However, practically, the wheel is compressed a little at the contact point of the two surfaces under stress. Because of that little sliding friction, the rolling friction is produce and less than sliding friction.

PROBLEMS

3.1 20 N force moves a body with an acceleration of 2 ms^{-2}. What is it its mass?

Given Data

Force acting on the body = F = 20 N

Acceleration of the body = a = 2 ms^{-2}

Required

Mass of the body = m = ?

Solution

From Newton's second law of motion

$$F = ma$$

So $$m = \frac{F}{a}$$

By putting the values, we have

$$m = \frac{20}{2}$$

$$m = 10 \text{ kg}$$

Result

Mass of the body = m = 10 kg

3.2 The weight of a body is 147 N. What is its mass?

Given Data

Weight of the body = w = 147 N

Gravitational acceleration = g = 10 ms^{-2}

Required

Mass of the body = m = ?

Solution

As we know that

$$w = mg$$

So $$m = \frac{w}{g}$$

By putting the values, we have

$$m = \frac{147}{10}$$

$$m = 14.7 \text{ kg}$$

Result

Mass of the body = m = 14.7 kg

3.3 How much force is needed to prevent a body of mass 10 kg from falling?

Given Data

Mass of the body = 10 kg

Gravitation acceleration = g = 10 ms^{-2}

Required

Force required to prevent the body from falling = R = ?

Solution

As we know that in stable position,

$$R = w = mg$$

By putting the values, we have

$$R = w = 10 \times 10$$

$$R = 100 \text{ N}$$

Result

Force required to prevent the body from falling = R = 100 N

3.4 Find the acceleration produced by a force of 100 N in a mass of 50 kg.

Given Data

Force acting on the body = F = 20 N

Mass of the body = m = 50 kg

Required

Acceleration of the body = a = ?

Solution

From Newton's second law of motion

$$F = ma$$

So $$a = \frac{F}{m}$$

By putting the values, we have

$$a = \frac{100}{50}$$

$$a = 2 \text{ } ms^{-2}$$

Result

Acceleration of the body = a = 2 ms^{-2}

3.5 A body has weight 20 N. How much force is required to move it vertically upwards with an acceleration of 2 ms^{-2}.

Given Data

Weight of the body = 20 N

Acceleration of the body = a = 2 ms^{-2}

Gravitational acceleration = g = 10 ms^{-2}

Normal reaction = R = w = 20 N

Required

Force acting on the body moving vertical upward = F = ?

Solution

As we know that

$$w = mg$$

So $$m = \frac{w}{g}$$

By putting the values, we have

$$m = \frac{20}{10}$$

$$m = 2 \text{ kg}$$

From Newton's second law of motion

$$F = ma$$

By putting the values, we have

$$F = 2 \times 2$$

$$F = 4 \text{ N}$$

Now net force required to move the body upward

= normal reaction + force producing acceleration

= 20 N + 4 N = 24 N

Result

Force acting on the body moving vertical upward = F = 24 N

3.6 Two masses 52 kg and 48 kg are attached to the ends of a string that passes over a frictionless pulley. Find the tension in the string and acceleration in the bodies.

Mass of first body = m_1 = 52 kg

Mass of second body = m_2 = 48 kg

Gravitational acceleration = g = 10 ms^{-2}

Required

Acceleration of the bodies = a = ?

Tension in the string = T = ?

Solution

When the two bodies are moving vertically then acceleration of the bodies is as,

$$a = \frac{(m_1 - m_2)g}{m_1 + m_2}$$

By putting the values in above equation, we have

$$a = \frac{(52-48)\times 10}{52+48}$$

$$a = \frac{40}{100}$$

$$a = 0.4 \text{ ms}^{-2}$$

When the two bodies are moving vertically then tension in the string is as,

$$a = \frac{2m_1m_2g}{m_1+m_2}$$

By putting the values in above equation, we have

$$T = \frac{2\times52\times48\times10}{52+48}$$

$$T = \frac{49920}{100}$$

$$T = 499.2\ N = 500\ N$$

Result

Acceleration of the bodies = a = 0.4 ms^{-2}

Tension in the string = T = 500 N

3.7 **Two masses 26 kg and 24 kg are attached to the ends of a string which passes over a frictionless pulley. 26 kg is lying over a smooth horizontal table. 24 kg mass is moving vertically downward. Find the tension in the string and the acceleration in the bodies.**

Given Data

Mass of the block moving vertically = m_1 = 24 kg

Mass of the block moving along table = m_2 = 26 kg

Gravitational acceleration = g = 10 ms^{-2}

Required

Acceleration of the bodies = a = ?

Tension in the string = T = ?

Solution

When one body is moving vertically and other body is moving horizontally then acceleration of the bodies is as,

$$a = \frac{m_1g}{m_1+m_2}$$

By putting the values in above equation, we have

$$a = \frac{24\times10}{24+26}$$

$$a = \frac{240}{50}$$

$$a = 4.8\ ms^{-2}$$

When the two bodies are moving vertically then tension in the string is as,

$$T = \frac{m_1m_2g}{m_1+m_2}$$

By putting the values in above equation, we have

$$T = \frac{24 \times 26 \times 10}{24 + 26}$$

$$T = \frac{6240}{50}$$

$$T = 124.8\ N = 125\ N$$

Result

Acceleration in bodies = a = 4.8 ms^{-2}

Tension in the string = T = 125 N

3.8 How much time is required to change 22 Ns momentum by a force of 20 N?

Given Data

Change in momentum = $P_f - P_i = 22$ N

Force applied = F = 20 N

Required

Time required = t = ?

Solution

As we know that

$$F = \frac{P_f - P_i}{t}$$

So $$t = \frac{P_f - P_i}{F}$$

By putting the values, we have

$$t = \frac{22}{20}$$

$$t = 1.1\ s$$

Result

Time required = t = 1.1 s

3.9 How much is the force of friction between a wood block of mass 5 kg and the horizontal marble floor? The coefficient of friction between wood and marble is 0.6.

Given Data

Mass of the block = m = 5 kg

Coefficient of friction = $\mu_s = 0.6$

Required

Force of friction = F_s = ?

Solution

As we know that

$$F_s = \mu s\ mg$$

By putting the values, we have

$$F_s = 0.6 \times 5 \times 10$$

$$F_s = 30\ N$$

Result

Force of friction = F_s = 30 N

3.10 How much centripetal force is needed to make a body of 0.5 kg to move in a circle of radius 50 cm with a speed of 3 ms^{-1}?

Given Data

Mass of the body = m = 0.5 kg

Radius of the circle = r = 50 cm = 0.5 m

Speed of the body = v = 3 ms^{-1}

Required

Centripetal force = F_c = ?

Solution

As we know that

$$F_c = \frac{mv^2}{r}$$

By putting the values, we have

$$F_c = \frac{0.5 \times (3)^2}{0.5}$$

$$F_c = 9\ N$$

Result

Centripetal force = F_c = 9 N